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ABSTRACT

The ability to become a scientifically literate citizen rests on the foundation students build from elementary, middle, and high school science experiences. The North Carolina Science Standard Course of Study (SCS) provides the concepts and theories all students should understand. Strands unify the goals and objectives and reflect a science as inquiry approach to doing and teaching science. The Strands (Nature of Science, Science as Inquiry, Science and Technology, and Science in Personal and Social Perspectives) are designed to connect and give meaning to the goals and objectives of the North Carolina Science Strand Course of Study. It is the intent of this document to offer insights into the ideas that encompass the Nature of Science. These ideas are fundamental to the applications of science to the real world. Understanding the Nature of Science enables scientific decision making which is necessary for our democracy to survive. Being an informed citizen requires conceptual understanding of the knowledge and skills elaborated upon in this Nature of Science document. (Author)

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Understanding the Nature of Science

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Understanding the Nature of Science

The ability to become a scientifically literate citizen rests on the foundation students build from elementary, middle and high school science experiences. *The North Carolina Science Standard Course of Study* (SCS) provides the concepts and theories all students should understand.

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> Children and scientists share an outlook on life. "If I do this, what will happen?" is both the motto of the child at play and the defining refrain of the scientist. The unfamiliar and the strange – these are the domain of all children and scientists.
> Gleick 1992

Science is a way we can answer questions and explore the natural world through:
- data collection
- observation
- experimentation
- analysis.

Science is interpretation leading to a body of evidence that can be subjected to:
- the test of observation
- reasoning
- peer review.

Science As A Human Endeavor

Scientific knowledge is constantly evolving.

People have several ways of knowing about their world including:
- scientific knowledge
- societal knowledge
- religious knowledge
- cultural knowledge.

Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of:
- empirical standards
- logical arguments
- skepticism.

The work of science relies on basic human qualities:
- reasoning
- insight
- skill
- creativity.

The work of science relies on scientific habits of mind:
- intellectual honesty
- tolerance of ambiguity
- skepticism
- openness to new ideas.

Scientists value:
- adherence to rigorous standards
- peer review
- truthful reporting
- making public the results of their work.

Scientists are influenced by:
- societal beliefs
- cultural beliefs
- personal beliefs
- ways of viewing the world.

Gains in scientific understanding represent a progression through previous events. All scientific knowledge is subject to change as new information is obtained.

Terms

Fact

In science, an observation that has been repeatedly confirmed. However, observations are gathered by our senses, which can never be trusted entirely. Observations can change with better observations or technologies.

Examples of scientific facts:
- The Universe is expanding.
- Earth is spherical and revolves around the Sun.
- Evolution is occurring.
- Earth's plates are moving.

Hypothesis

In science, a testable statement about the natural world that can be used to build more complex inferences and explanations.

People should view scientific knowledge as tentative truths and modify their beliefs as new evidence demands.

Theory
In science, a well-substantiated explanation of some aspect of the natural world that incorporates facts, laws, inferences, and tested hypotheses.

Examples of scientific theories:
- Electromagnetic Theory
- Atomic Theory
- The Theory of Evolution
- The Theory of Relativity
- The Theory of Plate Tectonics.

The term scientific theory is not used, as people often use the word theory, to mean a guess or a hunch.

Law
In science, a descriptive generalization about how some aspect of the natural world behaves under stated circumstances.

Examples of scientific laws:
- Ohm's Law
- Kepler's Laws of Planetary Motion
- The Law of Universal Gravitation
- Newton's Laws of Motion.

The Nature of Scientific Knowledge
A scientific theory:
- represents the most logical explanations based on currently available evidence.
- is supported by enough evidence to make its abandonment unlikely.
- provides a context for predictions.

> "Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards)

A scientific theory may be modified, as new evidence is found, but only with:
- compelling evidence
- verification
- peer review.

A scientific theory is never actually proven.

Validity in science is confirmed and established by the process of conducting similar experiments to obtain supporting results.

Before a theory can be included in the system of science, it must meet all of the following criteria:
- its ability to explain what has been observed
- its ability to predict what has not yet been observed
- its ability to be tested by further experimentation
- its ability to be modified as required by the acquisition of new data.

Essential Contributing Ideas for Understanding
Science As A Human Endeavor and The Nature of Scientific Knowledge
Kindergarten – Grade 5
By the end of grade five, students should understand that:

- Learning to view the world scientifically means to ask questions about nature, to seek explanations, collect and measure things, make observations, organize information and discuss findings with others.
- When a science investigation is done the way it was done before, we expect to get a very similar result.
- There is consistency in nature.
- Describing things as accurately as possible is important in science because it enables people to compare their observations with others.
- One way to describe something is to say how it is like something else.
- A model of something is different from the real thing but can be used to learn about the real thing.
- It is important to keep records of investigations and observations.
- Many people choose science as a career and devote their entire lives to it.
- Science has been practiced by people for a long time.
- Men and women have made a variety of contributions to science throughout history.
- It is important to try and figure out why scientific investigations sometimes yield unexpected results.
- Claims must be supported by evidence.
- Scientists' explanations about what happens in the world comes partly from what they observe, partly from what they think.
- Science will never be finished.

Middle School

By the end of the eighth grade, students should understand that:

- It is important in science to keep honest, clear, and accurate records.
- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and often it takes further studies to decide.
- Some scientific knowledge is very old and yet is still applicable today.
- New ideas in science sometimes spring from unexpected findings and they usually lead to new investigations.
- There are often several different ways of making sense out of evidence.
- Claims that are vague should be questioned.
- Choosing a useful model is one of the instances in which intuition and creativity come into play in science.
- Science is always subject to public review and scrutiny.
- Models are often used to learn about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.
- Some matters cannot be examined in a scientific way.
- Hypotheses can be valuable, even if they turn out to not be true, if they lead to fruitful investigations.
- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- Estimates can be based on data from similar conditions in the past or on the assumption that all possibilities are known.
- Women and men of various social and ethnic backgrounds and with diverse interests, talents, qualities, and motivations, engage in the activities of science, engineering, and related fields such as health professions.
- Reasoning should be questioned when:
  - fact and opinion are intermingled
  - the conclusion does not logically follow from the evidence given
  - findings are generalized to all members of a group, and
  - conclusions are based on small samples of data, biased samples, or samples for which there was no control.
- Many individuals of various cultures have contributed to the traditions of science and its applications.
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach many of the conclusions provides the roots for modern scientific and technological advances.

Grades 9-12

By the end of the twelfth grade, students should understand that:

- Curiosity, honesty, openness, and skepticism are highly regarded in science.
- Scientists assume that the universe is a vast single system in which the basic rules operate everywhere.
- Most changes that take place in the body of scientific knowledge are small modifications of prior knowledge. The accumulation of such small changes may lead to major new ideas.
- In science, the testing, revising, and occasional discarding of theories, new and old, never ends.
- Technologies, such as computers, make the design and testing of devices and structures and the simulation of complicated processes possible.
- The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.
- Reasoning in arguments should be criticized when based on faulty, incomplete, or misleading use of numbers, graphs, and/or logic.
- Some scientific events might have occurred just by chance.
- Alternative ways of explaining data and tradeoffs in decision making are viable.
- To be convincing, an argument needs to have both true statements and valid connections among them.
- Throughout history, diverse cultures have contributed scientific knowledge and technological applications.
- Applying scientific processes lead to an increasingly better understanding of how things work in the world but not to absolute truth.
- Logic can be used to test how well a general rule works.

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